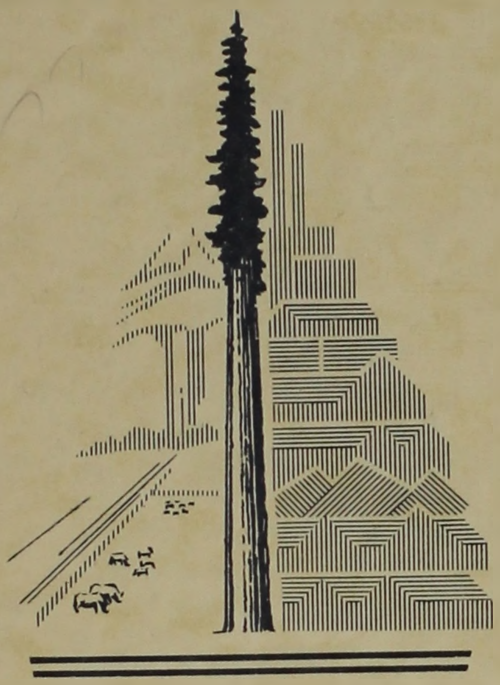
ANNUAL REPORT - 1951



U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
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PORTLAND, OREGON

MARCH 1952

CONTENTS

ANNUAL REPORT TO THE CHIEF OF THE FOREST SERVICE OF THE PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION FOR THE CALENDAR YEAR 1951

INTRODUCTION

Foremost in the list of accomplishments for the year is the Station's contributions to national rearmament. The Forest Utilization and Forest Survey staffs carried the major part of defense project work but practically everybody in the Station had some part in completing the tasks assigned this Station. The principal projects were the survey of log equipment, supplies, and manpower, and analysis of the adequacy of raw material for timber industries applying for certificates of necessity; both conducted for the National Production Authority. These and other defense projects are described in detail in the body of the report.

The defense work has confirmed earlier conclusions of both the Forest Utilization Unit and Forest Survey that the degree of raw material utilization in woods and manufacturing plant is increasing steadily. A majority of the applicants for certificates of necessity plan on using either low-grade logs or sawmill and plywood waste for raw material. More intensive utilization, which is taking place chiefly in the Douglas-fir region, will influence our research programs immeasurably. Trends such as this accent the need for flexibility in research programs.

Flexibility can be partly supplied through our research centers provided they are adequately staffed. Furthermore, the research centers are outposts in determining changing trends in timber and range management practice, thus enabling us to orient research programs better.

Although all the centers operated during the past year, we were understaffed at each of them, but in particular at the Siskiyou-Cascade and the Mid-Columbia. Both forest management and watershed management studies are planned for the Mid-Columbia center when funds become available. A series of small watersheds, ideally located for the work, have been tentatively selected for use in comparing effects of different systems of logging and grazing on water yields.

Logging operations under experimental plans were under way at all experimental forests. The Port Orford Cedar Experimental Forest was not staffed because of military furlough of assigned personnel. The harvesting program was continued, however, through cooperation of Siskiyou National Forest. A new forest was established in the Siskiyou-Cascade research province--the South Umpqua. The immediate problem at this forest is to inventory it, provide means of access, and make a

problem analysis and work plans. Here studies in management of the complex fir-pine forests commonly found in southwestern Oregon are planned, with particular emphasis on sugar pine.

Cutting operations on the experimental forests are well along in the layout and operational phases. Results so far have been of immediate value in applying advanced management principles to second-growth Douglas-fir and spruce-hemlock stands and to old-growth Douglas-fir stands. We can see our way clear now to emphasize study phases dealing with more fundamental silvicultural and ecological aspects of management. In the pine region, sanitation-salvage cutting was employed on the Pringle Falls Experimental Forest, and on the John Day Experimental Forest a sanitation-improvement cut was made. A report was completed for the sanitation-salvage work. We are now studying the desirability of initiating a cutting experiment to test the principles of "unit area control" in this region's pine forests.

One trend in the reforestation field causing great interest is the increased use given broadcast seeding by plane and helicopter. While we recognize that the prospect of prompt, cheap restocking is inviting, we believe many of these projects are carried out without assurance of success. Limited studies in broadcast seeding have been made by the Station since 1949, but research in this field needs to be strengthened materially.

The unfortunate fire history of the Douglas-fir region during 1951 showed that fire research must be strengthened. For one thing, it taught us that the large fire is still a major problem and further study must be made of organization methods, strategy, and tactics. It confirmed our view that fire weather is a key element, showed that we need even greater effort in climatoligical studies, and forcefully reminded us that solution of the slash disposal problem cannot be temporized.

Publication of "Forest Statistics for Southwest Oregon Unit" was a highlight of the year for the Forest Survey. It provides a bench mark for the appraisal of trends in the forest resource situation. This area of 8.1 million acres, of which 7.2 million is forest land, has been frequently labeled the "last forest frontier." Our report shows it has 153 billion board feet, log scale, Scribner, of saw timber, an increase of 22 percent over the 1933 figure of 128 billion. A comparison of primary growing stock (trees 5.0 inches d.b.h. and larger) shows a current volume of 29.6 billion cubic feet and a 1933 volume of 31.8 billion cubic feet, a decrease of 7 percent during the 15-year period. Changing standards of utilization and survey specifications are chiefly accountable for the increased board-foot volume. In southwest Washington--Clark, Cowlitz, Pacific, Wahkiakum, and Skamania--our inventory of saw-timber volume increased from 51.7 billion board feet in 1933 to 62.8 billion feet in 1949-50, an increase of 21 percent. Annual growth, both of saw timber and primary growing stock, shows a noticeable increase in both areas. It is reasonable to conclude that the trend in our resource situation is turning upward.

A number of important pieces of range research, including one departmental circular, were published during the year and the program for 1952 contemplates several major publications. We have about completed the preparatory or construction stage of the Starkey study in grazing management, and greater effort can be placed on the experimental phases. Here again, as noted in this Station's 1950 report, is an excellent opportunity to carry on watershed management studies to determine effects of different grazing systems on erosion, water yield, and water quality. Our expanded program of range reseeding research, begun in 1945, is now sufficiently mature that reliable data regarding species and methods for use in some parts of our summer ranges are available to guide large-scale planting. Most of these guides have been embodied in a Region 6 handbook that has just been processed, and they will form the basis for subsequent publications for public use. Studies of the effects of logging show that ground cover, both from the standpoint of forage production and watershed, has materially improved in the four years since logging but that it still has not overcome the initial damage. These data, even though primarily collected to permit an understanding of what happens on ponderosa pine ranges as result of logging, are also of material importance in the consideration of watershed management policies.

Work of the flood-control survey, integrated with the Columbia Basin Agricultural Program, has sharply outlined conditions and problems in resource management. The improvement program now being developed--including the national forest project work inventories--points the way to increased timber and forage production, to decreased damage from floods and erosion, to controlled yield of water, and to improved water quality. Shaping the program and preparing the report is now a major activity of the Station, in which all divisions are participating.

Aside from the direct basin program work of the flood-control survey, a small beginning has been made in watershed management studies. On the Blue River Experimental Forest, installation of precipitation and stream flow measuring equipment is under way. First studies here will be confined to effects of logging on stream flow and water quality. In one or two other areas studies are being made of the effects of fire on erosion losses from forest land. Studies of forest soil conditions, part of the regular survey work, are being expanded slightly. Through cooperation with other agencies, public and private, limited work has begun on studies of the effect of fire on forest soil and site conditions.

A major accomplishment in forest utilization was the progress made in the various studies of Fomes pini infected lumber and plywood. We believe that armed with the data on this subject developed at the Madison Laboratory and locally we can aggressively push the utilization of this material to the point where it will result in marked improvement of forest management practices.

Recapitulation of research progress and needs is a compelling reminder of the power of cooperation. Much of our progress is the result

of cooperative efforts among many agencies. It is clear that with a bursting field of research needs we must utilize every feasible avenue of cooperation and use our own resources skillfully. Two points will illustrate our intentions. We are establishing a research advisory committee at the Puget Sound Research Center, a step towards stimulating cooperative effort and shaping our own program to the best advantage. Secondly, we plan to give greater attention to improving administrative procedures as a means of conserving research time. This will include such tools as safety precautions, training measures, and critical review of work programs.

FOREST ECONOMICS

The normal work of the division during the year 1951 was materially upset by defense activities. These activities are discussed in greater detail in a subsequent section of this report. Of the several, the most time-consuming on which personnel of the division engaged was a survey on equipment, supplies, manpower, and related facilities for production of lumber, plywood, pulp, and other forest products in this region. For a part of the year the entire Forest Survey staff was engaged in this equipment-manpower survey.

Forest Survey

Field work on the Station's reinventory program got off to a late start because of the equipment-manpower survey. Field work was all in the State of Washington. A total of about 1,710,000 acres was covered. This work included roughly the western third of Lewis County, that portion of Grays Harbor County which was not covered in 1950, and complete coverage of Mason County. Survey techniques used and developed in the last couple of years, involving a continuous inventory system, the more precise accuracy specifications established as a Nation-wide standard in 1949, and use of photo-volume plots, were continued during 1951.

Projection of types from aerial photos to base maps was completed during the year for Skamania County and for a part of Grays Harbor County. Office compilations for type areas and timber volumes were completed for Skamania and Pacific Counties. A one-inch-to-the-mile scale type map was completed and published for Pacific County, and drafting for such a map was begun for Skamania County.

Office compilations have proceeded far enough so that some preliminary conclusions can be drawn on the timber volumes present in the five counties of southwest Washington compared with volumes present at the time of previous inventories. The volumes reinventoried in Clark, Cowlitz, Pacific, Skamania, and Wahkiakum Counties in 1949 and 1950 show a rather substantial increase in board-foot volume over the 1933 inventories, of the order of 21 percent. Rather large acreages on which timber present in 1933 was too small to contribute board-foot volume have reached merchantable size in the interval. Cubic-foot volume, however, remains almost exactly the same.

One survey report was released during the year: Forest Survey Report No. 104 entitled, "Forest Statistics for Southwest Oregon Unit." Completion of the writing and release of this report was one of the division activities which was delayed by several months because of the equipment-manpower survey.

In connection with preparation of this report, the division evolved a variant of existing methods for calculating growth in Douglas-fir stands. Essentially, the method is an application of yield-table procedures to old-growth Douglas-fir stands. The part of the work accomplished during this past year included developing the theoretical considerations in the method and applying them to the field data for the Southwest Oregon Unit. In application, the method involves plotting net stand volumes from the randomly selected inventory sample plots over their corresponding stand ages and determining a least-squares regression. The regression coefficient is used as the average annual net growth per acre.

The procedure of using photo volume plots to replace some field plots, first reported a year ago, was further refined and used as part of the regular survey procedure during the field work of 1951. Some further work was accomplished in additional refinement of this technique, including better figures for photo-volume tables. There are indications from the work done this season that the time required for field work will be reduced by about one-fourth through use of photo-volume plots. There is some increase in time required for office compilations. Since time saved in the field will be greater than added office time, the technique offers promise of a net saving in time, which in turn means faster coverage of areas surveyed. The saving in costs will be relatively greater through reduction of travel expense.

During the year the division met the usual steady flow of requests for survey information, averaging about ten a week, and including some rush requests for the direct defense agencies.

Division personnel prepared data for, or presented, open meeting discussions of the forest resource situation and statistics for a number of meetings during the year. One was a principal paper at the Western Forestry and Conservation Association annual meeting, by Cowlin, on the forest resources of the Western States. Another was a rather comprehensive summary of the forest resource statistics and trends in the nine southwest Oregon counties presented at the request of the Bonneville Power Administration. This discussion was given at a meeting of Bonneville's Regional Advisory Council in Eugene. A third was a panel discussion of statistics, conditions, and trends on western Washington forest land ownerships of less than 5,000 acres before the Puget Sound Section of the Society of American Foresters.

The Division again cooperated with the Forest School at Oregon State College in giving a one-week aerial-photo interpretation short course for interested foresters. Together with the Division of Forest

Management Research, the Division also cooperated with the office of the State Forester of the State of Oregon on the design of a survey of management plan purposes for the State-owned forest lands in the Tillamook Burn area. This is a detailed and comprehensive survey in which substantial use is being made of aerial photo techniques. Follow-up work on previously reported lumber recovery studies was carried on largely by the Forest Utilization Service.

Mortality studies received some attention during the year. A co-operative project involving the Division of Forest Insect Investigations of the Bureau of Entomology and Plant Quarantine, the Bureau of Land Management, the Division of Forest Pathology of the Bureau of Plant Industry, and the Oregon State Board of Forestry was continued. As part of this project, two of the cooperative mortality plots described a year ago were rephotographed, using different photography scales. These two plots were reinventoried in the field. Analysis continues on the results of this plot work, both to establish mortality trends and to work out ways to estimate mortality by photo interpretation.

An inter-division activity to which Forest Economics contributed time during the year is the work of the Douglas-fir Second-Growth Management Committee. Activity is now under way by this committee to bring out a revision of the 1947 publication "Management of Second-Growth Forests in the Douglas-fir Region."

Plans for 1952

Field work on the reinventory will be continued in the State of Washington and resumed in the State of Oregon this coming year. It is planned to complete Lewis County and to make at least a start in one county east of the Cascades. In Oregon, it is planned to do field work in Clatsop and Crook Counties.

On the office end of the work it is planned to complete for Grays Harbor, Mason, and Lewis Counties the following steps: compilations for type areas, photo volume computations, compilation of volumes, and completion of base map drafting. One-inch-to-the-mile scale type maps should be completed for Skamania, Grays Harbor, and Mason Counties. We expect to get out statistical reports covering the four counties that have been considered the Southwest Washington Unit--Clark, Cowlitz, Skamania, and Wahkiakum--and also statistical reports covering Pacific and Grays Harbor Counties.

Other work will include: developing details of a procedure with the States of Oregon and Washington for collecting and compiling statistics on forest products production; further exploratory work on logging waste surveys, particularly on the subject of techniques in making such surveys; continuing the cooperative work on mortality; continuing research on how to make more effective use of photogrammetric methods in conducting the Forest Survey; and more technique research in improved methods of estimating growth on a sampling basis.

Defense Activities

Early in the year 1951 the Divisions of Forest Economics and Forest Utilization jointly prepared a report for the Washington Office on the softwood plywood industry of Washington and Oregon. This report contained a complete directory of the softwood plywood industry of those two States as of January 1, 1951, together with information on production by the various plants listed and the timber supplies available to those plants. This industry is the most rapidly expanding and changing segment of forest industry of the Pacific Northwest at the present time.

The so-called "Equipment-Manpower Survey," referred to earlier in this report, was a part of a Nation-wide undertaking. The work was done at the request of the National Production Authority and the National Security Resources Board, and the data developed by the survey were intended primarily for the use of those agencies. Object of the survey was to determine the use of equipment, supplies, and manpower by the various primary forest products industries during the year 1950 in the several forest regions of the United States as a basis for estimating war-time equipment and manpower needs in logging.

Information assembled was compiled on an all-west basis, rather than by regions. Consequently, without additional compiling and tabulating effort, final results are not now available for either the Douglas-fir or the ponderosa pine subregions. Some preliminary information for the two subregions was developed prior to final tabulations and checking. Highlights of that preliminary information are presented in the following table:

Table 1.--Some interesting statistics drawn from the preliminary equipment-manpower survey compilations

(Data are for the year 1950)

	Douglas-fir subregion	Ponderosa pine subregion
Employment in logging. Number of worker-years/million feet of logs, log scale	4.00	3.18
Proportion of tractor logging	35%	97%
Proportion of cable logging	65%	3%
Proportion of falling by power saws	84%	98%
Proportion of falling by hand saws	16%	2%
Proportion of bucking by power saws	72%	98%
Proportion of bucking by hand saws	28%	2%
Overrun in lumber manufacture on 2,425 MM in the fir region, and 832 MM in the pine region	17.03%	6.77%

In the course of this survey in the entire region, 126 sample plants and 371 logging operations were enumerated. The sample plants included 96 sawmills, 12 pulp plants, and 9 plywood plants. Cooperation from these members of forest industry who had to take time to be interviewed and to provide requested information was outstanding.

FOREST UTILIZATION SERVICE

Encouraging progress has been made during the year in bettering utilization of Pacific Northwest timber resources. All wood-using industries have been generally profitable according to all reports and industry has been investing some of their earnings in equipment or new plants to better utilize their raw material supply.

To justify the large investment for new equipment and plants, industry needs a more secure raw material supply. Therefore, there has been much activity during the year by individual companies in the procurement of timber or land stocked with young growth. In addition, much consideration has been given to the possibility of using more "mill waste" and "woods waste" material as a part of the needed raw material supply.

Expansion in the pulp industry and hardboard plants is most encouraging for better utilization. Most of the proposed expansion in pulp production (596 thousand tons of pulp per year) is based on the utilization of chips obtained from "waste" at sawmills and plywood plants or from little-used species. There are now 4 hardboard plants in production on the West Coast, 7 under construction, and several more in the planning stage. The raw material for all of these plants is "mill waste" or other material unsuited for plywood or lumber.

The Forest Utilization Service continues to function as the field representative of the Forest Products Laboratory of the Forest Service in Madison, Wis., and maintains contact between industry and the Laboratory. In addition, utilization and forest products research work under way by the Oregon Forest Products Laboratory and the Washington Institute of Forest Products are currently reviewed and generally correlated with that done by the U. S. Forest Service.

While work during the year varied considerably, major consideration was given to the following projects:

1. Defense projects.

2. Utilization of Douglas-fir cull logs.

3. Laminating lumber for both military and civilian uses.

4. Kiln drying lumber.

5. Fiberboard manufacture.

Defense

The Forest Utilization Service unit spent a major part of time on defense work and was primarily responsible for the following defense projects:

(a) Use of western woods for military furniture. Members of the Forest Utilization Service unit have worked with both industry and the General Services Administration on the use of western woods for military furniture. Until recently specifications did not admit western woods, which are used extensively as raw material by western furniture manufacturers, thereby eliminating them as possible suppliers. A big saving in freight cost to the Government is possible by using western-made furniture as much of it is purchased for use in the Pacific area. During the year local furniture companies requested that specifications be modified to permit their bidding on military contracts. General Services Administration held two meetings in this region during July to discuss proposed changes in the specifications. Representatives of the furniture industry and Forest Service were present.

It was recommended that local alder and maple be considered suitable for many uses that now are specified in eastern maple and yellow birch, which are in short supply. Sitka spruce was also recommended as a suitable core material for some uses. The specifications have been amended to include these species which will make it easier and cheaper for the military agencies to obtain their needed furniture.

(b) Certificates of necessity for wood-using industries. The National Production Authority requested the Forest Service to investigate all applications for certificates of necessity for the wood-using industries. The Forest Service obtained information on the availability and suitability of the timber supply covered by the application. The work of this type for Oregon and Washington was divided between the Timber Management office of Region Six and the Station. During the year applications submitted for Oregon and Washington amounted to 53 in number for expanded facilities valued at approximately $144,000,000. This total was made up of 20 applications for new or expanded facilities for pulp plants, 27 for plywood plants, 2 sawmills, 3 fiberboard plants, and 1 creosoting plant.

(c) Survey of lumber used at military establishments. The first part of the year Forest Utilization Service personnel surveyed 10 military establishments in Oregon and Washington, covering the use of wood as a part of the survey conducted by the Forest Products Laboratory for the Corps of Engineers, U. S. Army. Purpose of the survey was to determine present uses, practices and facilities for handling lumber and to determine the type of problems that are common to many or all installations, with a view toward increasing the utilization of the lower grades of lumber where they meet use requirements.

In addition to answering the questions set forth, the survey will lead to the preparation by the Forest Products Laboratory of a Wood Use Manual for use by the Corps of Engineers, which is the purchasing agency for lumber and other forest products for the entire Department of Defense.

Utilization of Douglas-fir Cull Logs

Attention this year to the utilization of Douglas-fir logs left in the woods in logging operations, because they contained a considerable amount of white pocket (Fomes pini) infection, has been directed into two specific fields. Further exploration of strength and other mechanical properties of the infected wood in such logs was carried out at the Forest Products Laboratory. These studies are currently being brought to conclusion and their results will be helpful in exploring potential markets for the use of this type of wood.

In the early part of the year there already was some commercial utilization of white pocket Douglas-fir as veneer for inner plies of a special type of Douglas-fir plywood manufactured and sold outside the standards currently used for the production of Douglas-fir plywood. This new utilization prompted a study to determine how much useful veneer suitable for the production of such plywood might be obtained from the cull logs left behind in logging operations in the upper Willamette Valley of Oregon. The study was carried out at Culp Creek, Oreg., in which approximately 100 logs of peelable type were selected in several logged-over areas and were cut into veneer for the production of nonstandard plywood sheathing.

This special grade of plywood was of 3-ply construction and while the veneer in the face and back plies was required to be free of white pocket material, the center ply (crossband) would admit white pocket material as long as the veneer was smoothly and firmly cut and otherwise did not contain knot holes or other defects beyond those allowed in standard plywood. Actually the face and back of the plywood were required to be of the same grade and quality of veneer required in standard sheathing grades of Douglas-fir plywood; that is, "C" and better grade for the face and "D" for the back.

The logs included in this study scaled a gross volume of 180,500 ft.b.m. When scaled in accordance with current log grading rules these logs were considered culls. For grading purposes the wood in these logs was classified into the following types:

1. Sound wood--no stain or decay.

2. White pocket infection--stain stage only--material usable in veneer.

3. White pocket--decay advanced to white pocket formation but wood structure firm and strong--material usable in veneer.

4. White pocket--decay advanced to white pocket formation but wood structure soft and punky--material not usable in veneer.

When graded on a basis on which firm white pocket Douglas-fir would be admissible, the net scale of the study logs amounted to 145,410 ft.b.m. Admitting firm white pocket material in the scale, a considerable portion of these logs--26,440 ft.b.m.--were graded as No. 1 Peeler Fomes pini, 60,120 ft.b.m. of logs as No. 2 Peeler, and 35,910 ft.b.m. as No. 3 Peeler. The remainder were of lower grade, some turning out to be nonpeelable.

The study logs were rotary cut into 1/8-inch veneer, using the same equipment and methods employed in the manufacture of standard Douglas-fir veneer. With the same lathe settings, firm white pocket wood was cut into veneer quite satisfactorily along with the sound uninfected wood. The volume of veneer produced per day from the cull logs was not as great as when cutting sound logs, due partly to lack of experience in handling this defective material and also to the greater waste. A considerable number of logs contained extreme ring shake so that cutting had to proceed at a slower rate than normal just as is the case when entirely sound logs containing ring shake are peeled.

The purpose of the study primarily was to determine how much useful veneer might be recovered from the logs. The study did not attempt to establish the economics prospects of operating a plywood mill on salvaged logs.

To get a comparison of veneer recovery and net log scale all veneer cut was measured on a board-foot basis, the same as is used for lumber. Eight thicknesses of 1/8-inch veneer, each 1-foot square, were considered 1 board foot. The No. 1 Peeler logs with a net scale of 26,440 ft.b.m. produced 32,680 ft.b.m. of veneer, of which 45 percent was graded as face stock (grade "C" and better), 19 percent backs (grade "D"), and 36 percent core. Much of the white pocket material admitted in the core occurred in streaks, interspersed with sound wood. While a relatively small portion of the core stock was entirely of white pocket material, a considerable portion was of short and narrow veneer entirely free of white pocket. The 60,120 ft.b.m. of No. 2 Peeler logs yielded 49,982 ft.b.m. of useful veneer, of which 39 percent graded as face, 18 percent backs, and 43 percent core. The 35,910 ft.b.m. of No. 3 Peelers produced 28,301 ft.b.m. of useful veneer, of which 34 percent graded as face stock, 19 percent backs, and 47 percent core. These results indicate that much potentially useful material is contained in these cull logs and that further exploration of the economics of salvaging them for the production of plywood suited possibly to new or limited uses is warranted. Further analysis of the data is expected to show that the recovery of veneer from such logs can be developed to a more favorable economic basis by further modifying the basis for grading the logs.

The position and dispersion of white pocket infection in the log (including both useful and nonuseful stages) had a great deal to do with the quantity of useful veneer which could be recovered. Since the center of the log is not cut into veneer in a rotary lathe but is waste as lathe core, white pocket infection in this area did not have any effect on the veneer recovery. Logs in which the white pocket is well scattered throughout the log in small, pencil-like areas, without large sound areas, will degrade all veneer from those areas to core quality, making the salvage of such logs unpromising. However, logs containing white pocket concentrated in one or a few areas produce sound veneer in between them which is suitable for faces and backs and appear most promising for this type of utilization. Many such logs contain such high-quality wood in the sound wood zones that they yielded considerable amounts of veneer of the highest quality required for faces for standard grades of plywood.

Laminating Lumber for Structural Uses

Forest Service research on the strength properties of glued laminated Douglas-fir structural members is being followed by major developments in the wood construction field. Strength tests conducted at the Forest Products Laboratory during the past few years on glued laminated beams fabricated in the Pacific Northwest have given results which are now enabling engineers to use working stresses as much as 50 percent higher than normal for solid wood. A large part of this increase in strength is due to the thorough dryness and freedom from checking of the glued laminated member, since the lumber from which it is made must be well dried before gluing. When solid members are used they are usually so large that they must be fabricated in the green condition in which the wood furnishes less strength than when thoroughly dry.

The benefit of designing wood construction at the higher working stresses is reflected in a statement by a commercial producer of glued laminated Douglas-fir structural material as follows:

> "Structural timber construction is now competing successfully with steel as a result of improved engineering, fabricating, and erecting techniques. This is now true even though the price of lumber has increased five times since 1940 while the price of steel has increased twice during the same period. Lumbermen should realize that pound for pound, lumber is stronger than steel. Wood is the only structural material which can successfully withstand a 100 percent overload. Five years ago glued laminated production in our plant was less than 10 percent of the total. This year with greatly increased production glued laminated products will constitute at least 60 percent of the total."

This progress in the use of wood for structural purposes becomes more significant when we consider that now glued laminated structural members of smaller size than solid members can carry the required loads,

and, further, that the lumber required for gluing them can very satisfactorily come from the smaller, second-growth forest crop on which we must depend more and more in the future. While the present benefits of fundamental research on the strength properties of this new type of material are reflected largely in construction for dry use, many benefits also can be extended to exterior uses.

Kiln Drying Lumber

The Forest Utilization Service unit continued to receive numerous requests from industry on kiln drying problems. Many of the newer sawmill companies have had very limited experience in seasoning lumber and, in addition, much more second-growth timber is being cut, which creates problems different than found in drying old-growth lumber.

Degrade in surfacing kiln dried common grades of lumber has been an important factor in establishing the cost of drying. Douglas-fir lumber producers have minimized this item by not fully drying the boards and dimension, drying such items to a level of 19 percent, thereby retaining the knots in place. Basic information leading to this practice was developed in Forest Service studies made over 25 years ago. Although there has been extensive improvement in dry kiln equipment since then and lumber grading rules have been changed, no additional degrade study results have been published.

During the past year we have considered with the Forest Products Laboratory the need for additional degrade studies at mills, exploring also the possibilities for developing a drying technique which can satisfactorily and economically produce more thoroughly dried framing lumber. We hope to find opportunities to undertake field studies of this kind.

Close contact has been maintained with industry by the unit through active participation in the dry kiln club meetings of the industry. Also, members of the unit have assisted in the dry kiln field courses sponsored by the Forest Products Laboratory at Madison and the Oregon Forest Products Laboratory.

Hardboard

Interest continues high in the production of hardboard from unutilized material at sawmills and plywood plants and from cull material ordinarily left in the woods. There is an abundant supply of this raw material which appears to be cheap and well suited for the production of fiberboard.

The first board plant in the Northwest was constructed in 1945. A second plant started producing board in 1949. These plants proved so successful that numerous other mills and plywood plants made plans for the production of hardboard. At present there are about a dozen plants in operation or under construction. All of these plants except one are

planned and designed to use "waste" developed at sawmills or plywood plants as their raw material supply. The one exception is a plant to be constructed in 1952 at Klamath Falls, Oreg., to use unmerchantable white fir logs. White fir in the Klamath Basin is very defective and therefore has little commercial value at present. It is claimed that this defective white fir will produce a board with qualities superior to those now commonly made from Douglas-fir.

The cost of a board plant is much less than for a pulp mill and board manufacture does not have the water supply and stream pollution problems encountered in the production of pulp. Hardboard can be produced by what is known as the dry process. Practically the only water requirements for this process are for the production of steam and other general factory use. This process makes it possible to produce fiberboard in areas where there is a water shortage, such as in the pine type on the east side of the Cascades. The Klamath Falls plant will use the dry process.

Another interesting plant has just recently started producing hardboard. This plant, at Dee, Oreg., operating in conjunction with the company's sawmill, uses "mill waste," including bark, for its raw material. This is the only plant in the Northwest that can utilize the bark for hardboard; all the rest require bark-free chips. This process should give added incentive to utilization of thinnings from young-growth stands. If markets can be developed, the production of hardboard can be greatly expanded for the potential raw material supply is enormous.

Information has been furnished industry and chambers of commerce on the amount of "waste" material currently developed in producing lumber and plywood which would be suitable for board manufacture.

Plans for 1952

Work of the Forest Utilization Service unit for the coming year should be much the same as in the past. The present working relationship between industry, the Forest Products Laboratory, and other institutions doing research in wood utilization will be maintained. Major emphasis will be given to:

1. Utilization of cull old-growth Douglas-fir logs.
2. Utilization of western hardwoods.
3. Development of fiberboard plants.
4. Douglas-fir log-grade study.
5. Laminating and uses for laminated material.
6. Kiln drying problems.

In addition, it is expected that considerable time will be spent on defense projects concerned with forest products.

FLOOD CONTROL SURVEYS

The Division of Flood Control Surveys has now completed two full years as a working unit. Principal activities this past year included continuation of previous work in coordination of all flood-control survey work for the Columbia Basin agricultural program, sediment sampling in various streams, and hydrologic analyses of stream flow from sample watersheds. In addition, the survey group of seven men worked with the USDA Columbia Basin Field Committee in developing data on land area by land use classes, land ownership classes, and political subdivisions; on preparing maps; and in development, preparation, and writing of various sections for the comprehensive agricultural program report. The group also furnished technicians to work with the administrative branch of the Forest Service in developing the program applicable to forest land. The work of the survey has been coordinated throughout with that of other Columbia Basin survey groups, other branches of the Forest Service, agencies represented on the Field Committee, and other State and Federal land-managing agencies.

Advance Studies

The final report on the soil freezing study was published in October. In its second year, this study was restricted to range lands in eastern Oregon. Snow depth, plant cover type, and topographic aspect were found to be more important factors in the extent of soil freezing than were soil depth and drainage characteristics. Impermeable soil frost occurred most frequently and lasted longest in light-textured soils on north slopes under a mixed conifer stand, but at no time were any extensive areas of impermeable frozen ground observed. Frost heaving was most commonly observed on south slopes and shallow soils. While the winter was warmer than normal, temperatures dropped below freezing nearly every night and below zero occasionally.

Sediment sampling was discontinued the first of June and begun again the first of October. Several streams in eastern Oregon and eastern Washington are now being sampled, but sampling in western Washington has been discontinued. A summary report on last season's observations was published in November. This report compares graphically the suspended sediment load with a stream flow through the season.

At the Blue River Experimental Forest, Stevens Q12M recording precipitation gages have been installed at two locations. One is in the valley bottom at 1,500 feet elevation, the other on a northerly exposed ridge at 2,800 feet elevation. The job of installation of trapezoidal flume stream gages in the three small study watersheds is now being advertised, and it is hoped to have the gages in operation next spring. Clearing of down logs and other debris around the gage sites has been completed. Records from the Lookout Creek gage for water year 1950 show the runoff for the entire experimental forest equal to 115,000 acre-feet, or 89.6 inches depth, with an average flow of 6.6 second-feet per square mile. Maximum summer water temperature was 62° F. in late August. Peak discharge of 1,980 second-feet, or 82 second-feet per square mile, occurred in late February.

On the Portland forest park burn, a study of erosion was set up in cooperation with the city forester. Photographs were taken of channels below two 50- to 100-acre burned watersheds and one 200-acre unburned watershed, and ground profile transects were laid out on five different burned slopes. Measurements made after heavy storms indicate that so far no serious erosion has occurred either in the channels or on the slopes. However, the story is different for the emergency fire roads built in the area; on these there has been considerable gullying where drainage has concentrated in the wheel ruts. This could have been prevented had there been adequate drainage installed in the roads.

Survey Field Work

For hydrologic analysis 21 sample watersheds were selected east of the Cascades--7 in Washington and 14 in Oregon--and reconnaissance surveys made to determine soil and plant cover characteristics pertinent to the analysis. Soil samples were collected, and their permeability and moisture storage capacity determined in the laboratory.

Highway, road, and railroad flood damages were collected for counties in Oregon and Washington. Reconnaissance surveys were made on national forest lands to round out the damage picture and point up the problem areas. A few sample watersheds were chosen for tentative flood-control program development where it seemed likely that structural projects would be needed and justified.

Field reconnaissance of eastern Oregon and eastern Washington took up a major part of the field season. The object was to familiarize technicians with the physical conditions of the various watersheds, to enable translation of map information on cover type and condition, soils, geology, and erosion into program needs and evaluation. Breakdowns of various kinds for cover, soils, physiography, and other characteristics were based in part on these reconnaissances. In addition, they enabled the selection of sample watersheds for further study of program development and evaluation.

Survey Office Work

Under Field Committee direction, basin maps were developed showing land use classes, forest type classes, range type classes, physiography, and geology. More detailed maps were drawn up for the westernmost of the minor basin subdivisions. Maps showing average annual rainfall and seasonal rainfall pattern, seasonal temperature pattern, length of frost-free growing season, and area with half or more of the precipitation falling as snow were drawn up in connection with the comprehensive agricultural program report sections assigned to the groups.

Hydrologic analysis, relating variation in peak stream flow to changes in watershed cover, was continued through the year, with principal accent on streams in eastern Oregon and Washington. For these streams, the cover variable expressing cut and burned forest area in the watershed was found to be significant. For west-side streams, a variable

expressing forest age and stocking showed a fair degree of significance; but more recent studies in which watersheds are grouped by physiographic characteristics give promise of a more significant forest cover variable. Other studies, in which the effects of differing meteorological elements were removed, showed peak stream discharges to be increasing over the period of records, while dry season flows were found to be decreasing over the same period. Both trends were associated with a decrease in forest cover.

Cooperation

Four Division members attended the joint session in Victoria, B.C. of the Western Snow Conference and Columbia River Basin Water Forecast Committee in April. With M. W. Nelson and R. A. Work of the Soil Conservation Service, H. G. Wilm was co-author of a paper, "Use of Snow Surveys in Planning Regulation of Columbia River Floods," presented at the meeting.

The Division took active part in the Forest Soils Committee for the Douglas-fir Region, one man being assigned to committee membership, and another going to the seminar in forest soils held at the University of Washington. Principal task of the committee now is the preparation of a manual of standard procedures for chemical, mechanical, and physical soil analyses, to gain uniformity of approach in soils studies. The flood-control group furnished soil samples for testing various methods of chemical analysis, wrote up specifications for sampling procedure and soil permeability tests, and with other public and private agencies worked out designs for studies of the effect of fire on soil conditions and site productivity.

At the request of the Division of Engineering in the Regional Office, two forest soils specialists were added to the group during the summer to make a study of soil conditions on the Fremont, Willamette, Mt. Hood, and Olympic National Forests as related to road construction and drainage specifications. Detailed reports were prepared for each forest, a generalized regional soils map was drawn up and numerous color slides were made to use in training work. Specifications, particularly for road location and drainage, were correlated with soil texture and erodibility.

The Flood Control Division had one member on the Columbia Basin Inter-Agency Committee's Pollution Control Subcommittee; he presented a paper on "Use of Water Supply Watersheds for Road Construction and Logging Operations" at their September meeting. The subcommittee has assigned the Division member the writing of a report on present watershed conditions in the Northwest with regard to pollution and sedimentation, on recommendations for watershed management to correct or avoid dangerous conditions on research needed in pollution and sedimentation and on existing regulations affecting watershed activities. The Washington Pollution Control Commission and the Oregon Sanitary Authority are cooperating in this work.

In view of the extremely bad fire weather throughout most of the field season, fire demands on the Division were modest. But fire did get us involved in other ways--a grass-seeding study and a cooperative study of mustard-seeding. The Bureau of Land Management seeded several thousand acres of freshly burned-over Douglas-fir land in southwestern Oregon to mustard in October, and we are following the work with considerable interest. By the end of November, leaf rosettes which afford quite a bit of soil protection had already formed. This is a wetter and more northerly location than has previously been seeded with mustard.

In answer to a request by the City of Tacoma Water Department an inspection was made of a railroad logging operation in a tributary to the city's domestic supply, Green River watershed. Serious stream damage was observed where railroad cut material had been overcast into channels below. Drainage was inadequate on the raw cut and fill slopes and there was considerable erosion with consequent sedimentation immediately downstream and turbidity in the main river. Checkdams in the channels and grass-seeding and tree-planting on the bare soil of the slopes were recommended to reduce further soil movement. Damage of this kind is better prevented by proper layout and construction than by subsequent attempts at control. Later in the year, the Water Department sanitary engineer was taken on a trip of the Oregon City watershed on the Clackamas River to see logging under strict specifications for watershed protection.

Plans for 1952

Completion of the flood-control portions of the Columbia Basin Agricultural Program, completion of hydrologic analyses, preparation of final reports on the outline sections assigned to the Division, and evaluation of the flood-control program will be the major jobs for the coming year. Work on advance studies such as sediment sampling and development of logging and access road specifications will be continued. Beyond finishing the stream-gage installations in the small watersheds at Blue River, no further work in watershed studies is planned at this time.

After the basin-wide program and reports are finished, attention will be turned to more detailed program material and supplemental reports on the 11 basin subdivisions. First efforts of the Division will be on the Grande Ronde-Wallowa Burnt River area in northeastern Oregon. For this work, further field study will be made on sample watersheds where flood damage data indicate that flood-control programs are highly important.

RANGE RESEARCH

Accomplishments by the Division of Range Research during 1951 have been gratifying, despite a reduction in research force. As in 1950, activities continued to be concentrated on the rehabilitation and management of summer ranges. Very little new field work was begun. Termination continued of some of the less productive studies and some of the studies where further observations had reached the point of diminishing returns.

In addition to the field work completed during the year, one departmental circular, three articles in technical journals, five articles in other outside publications, and three multilithed releases were published. Personnel of the Division also devoted considerable time to the completion and issuance of the Handbook of Range Reseeding Equipment and other work of the Range Reseeding Committee, and to the preparation of material for the Columbia Basin Comprehensive Agricultural Program.

The outstanding results and conclusions from field work during 1951, and from the analysis of data collected in previous years, are presented below.

Grazing Management Studies

Major emphasis in grazing management research continued to be in developing physical facilities for the Starkey grazing study and in perfection of suitable techniques. Additional roads, fences, corrals, and water developments were constructed for the south unit of pastures. The north unit of pastures was grazed for the second year of the calibration period to determine the true grazing capacity of each pasture. Work was continued to develop a better understanding of the vegetation and how it should be sampled. Using the procedure developed during 1948, 1949, and 1950, further tests were made on one of the experimental pastures to determine the efficiency of the method in measuring change from one year to another, and to test double sampling as a tool to increase sampling efficiency.

Forage utilization on the Flagtail allotment was much heavier in 1949 than in 1950 and the pattern of use varied considerably between years. This allotment, on the Malheur National Forest, is fairly typical of other rotation-deferred allotments in the Blue Mountains in central Oregon. In the open-forest type (21,080 acres), elk sedge (Carex geyeri) was the only species utilized to any extent in either year, while pine-grass (Calamogrostis rubescens), an equally abundant species, received practically no use (table 1). Even though the average use of elk sedge in the open forest type, over the allotment as a whole, was 14 percent each year, utilization was not consistent in the first and last parts of the grazing season. In 1949, elk sedge was utilized approximately the same on the two units of the allotment, but in 1950 it was used only 5 percent on the unit grazed the first half of the season and 22 percent on the unit grazed during the last half of the season.

Table 1.--Summary of utilization from open forest, sagebrush-bitterbrush and meadow types, 1949-1950

Type and species	1949 Average utilization percent	1949 Range in values	1950 Average utilization percent	1950 Range in values
Open forest				
Elk sedge	14	0-40	14	0-45
Pinegrass	1	0-10	1	0-15
Mountain brome	17	0-30	20	0-40
Antelope bitterbrush	19	0-35	0	0
Sagebrush-bitterbrush				
Bluebunch wheatgrass	37	0-85	18	0-65
Mountain brome	12	0-35	9	0-60
Bottlebrush squirreltail	48	0-80	10	0-60
Subalpine needlegrass	26	0-70	16	0-45
Sandberg bluegrass	45	0-90	5	0-25
Antelope bitterbrush	46	0-85	30	0-70
Big sagebrush	0	0	0	0
Meadow				
Kentucky bluegrass	81	40-95	60	15-85
Thin bentgrass	76	60-90	37	10-70
Sedge	64	10-85	45	10-70
Rush	60	15-75	8	0-10

The sagebrush-bitterbrush type (1979 acres) received heavier use than the open forest type in 1949, but in 1950 there was little difference in use of the two types. Bluebunch wheatgrass (Agropyron spicatum) was utilized 50 percent or more on 37 percent of the sample plots in 1949, while in 1950 only 10 percent of the sample plots were utilized 50 percent or more. Although there was little difference in the range of utilization on antelope bitterbrush (Purshia tridentata) between years, in 1949 only 3 percent of the plants sampled were ungrazed, while 26 percent were ungrazed in 1950.

The meadow type (882 acres) was the most heavily used type each year. Kentucky bluegrass (Poa pratensis) was used 75 percent or more on 86 percent of the sample plots in 1949, while in 1950 only 10 percent of the plots fell in this category. Utilization of thin bentgrass in the meadow type varied more between years than any other species. In 1949, the lowest use recorded was 60 percent, while in 1950 only one sample received use of greater than 60 percent.

The optimum number of plots per cluster for sampling the types of this allotment was found to be three for the open forest and sagebrush types and one for the meadow. The number of clusters needed for

a 5 percent sampling error (absolute value in percent of utilization) with odds of 2:1 was found to be 10 for the open forest, 20 for the sagebrush-bitterbrush, and 12 for the meadow. Four times as many clusters would be needed to provide a 5 percent sampling error with odds of 19:1.

An 8- to 10-inch spike and a block of salt are the ingredients for a readily moved salt ground for cattle. On the Starkey Experimental Forest and Range, the range rider devised a system of salting that facilitates the better distribution of cattle on ponderosa pine summer range. The block of salt, with a hole in it, is placed on a spike that is driven in a tree stump or log. The block of salt remains in place until consumption is almost complete. Waste is greatly reduced. There is no need for using exactly the same location each year because the spike can be driven into another stump or log easily, and the salt placed on it. As a result, the exact placement of the salt can be moved a short distance whenever needed and the customary "sore" spots effectively avoided. Moreover, salt grounds can be moved as the season progresses, and the cattle can be drawn to lightly used areas. A range rider with knowledge of his range and the salting and grazing habits of his cattle can easily improve uniformity of utilization of forage by placing the salt in strategic locations.

Range Condition and Trend Studies

New methods of getting more accurate records of floristic composition with the line transect are being studied. In the analysis of data from the Flagtail study, it became apparent that where vegetation density was low, the records for the calculation of floristic composition were inadequate. During the summer of 1951, a study has been made of three alternative procedures for getting better records of species composition. At least one of these methods appears to have sufficient promise that it will be given further trial during the summer of 1952.

Range Reseeding Studies

The final draft of a range reseeding handbook for Region 6 has been completed and the handbook is now processed. This handbook, prepared jointly by administration and research, includes results from all range reseeding studies in the region. It also includes applicable results from other agencies, and experience gained on full-scale seeding projects.

Completion of many of the existing studies in range reseeding, analysis of the results, and preparation of publications was intended for 1951. The loss of one of our men in June and our lack of success in filling this position have, however, prevented attainment of this goal. Even so, many worth-while results presented below have been secured.

Success of grass seeding often depends upon the degree to which competition from weedy plants is reduced. Data from the Doneen cheatgrass eradication study in Douglas County, Washington, give further

support to this general conclusion. Records taken on stands of crested wheatgrass (Agropyron cristatum) and intermediate wheatgrass (A. intermedium) in 1951, when the perennial grasses were 5 and 6 years old, show very clearly the degree to which presence of cheatgrass hinders establishment of the two perennial grasses. A significant negative correlation was found between the number of cheatgrass plants per square foot of soil surface in the year following seeding of the perennial grasses and the quality of the perennial grass stand 5 and 6 years following reseeding.

Method of seeding modified the effects of cheatgrass. For example, the data showed that the perennial grasses, sown by a deep-furrow drill on plots where the only seedbed preparation was burning of the cheatgrass, could tolerate more cheatgrass than where the perennial grasses were seeded by single-disk or double-disk drills, or by broadcasting and harrowing. The furrow openers on the deep furrow drills apparently destroyed the cheatgrass in a line along the drill row near the perennial grass seedlings and left them more moisture.

Six perennial grasses have been found best adapted for reseeding on depleted sagebrush-grass range in a study on the Doneen area that has been under way since 1946. Of the 15 carefully selected species tested, the following 6 have received the best ratings: intermediate wheatgrass, pubescent wheatgrass (A. trichophorum), crested wheatgrass, Whitmar wheatgrass (A. inerme), Siberian wheatgrass (A. sibericum) and Sherman big bluegrass (Poa ampla). Precipitation on the study area averages about 10 inches annually, and the light-textured soil is of the Ritzville series.

In 1950, the five best species in relative rating also proved to be the highest forage producers among those planted in the fall of 1947 and the spring of 1948. The highest air-dry forage yield of 945 pounds per acre was made by Siberian wheatgrass. The 800-pound yields of pubescent and intermediate wheatgrass were next high.

The six grasses, listed above, which have done best in this study all stay green later into the season than does cheatgrass. This is an important requirement for reseeding cheatgrass-type range lands because perennial grasses are needed which can lengthen the spring grazing period and reduce the fire hazard which abundant cheatgrass provides during the late spring and summer periods.

Ability of planted grass seed to maintain viability through a very dry season and then germinate later is important. Data from the Doneen area give some leads on the abilities of four range grasses to maintain seed viability where precipitation is not always sufficient to induce germination in the season immediately following planting. Whitmar wheatgrass, pubescent wheatgrass, Sherman big bluegrass, and sheep fescue (Festuca ovina, P-274) were seeded in the spring of 1949, a year of abnormally low precipitation. Counts on numbers of seedlings emerging were made later in 1949 and again in 1950.

While each of the four species showed as many or more seedlings emerging in 1950 than emerged in 1949, the data for sheep fescue and Sherman big bluegrass are unusually interesting. The seedlings of sheep fescue emerging in 1950 were twenty times as abundant as those in 1949; those of big bluegrass were ten times as abundant as in 1949.

The ability of these four grasses to maintain seed viability during drought and to germinate the following year when moisture conditions are favorable raises the probability of getting good stands of seeded grasses.

Some fairly conclusive results on species adaptability for grassland areas within the lower ponderosa pine zone of central Washington have been secured. After six years of observations and measurements, the best grasses have been intermediate wheatgrass, pubescent wheatgrass, Tualatin tall oatgrass (Arrhenatherum elatius), crested wheatgrass, and Whitmar wheatgrass. Among those species that have made poor stands or only medium at best are Canada bluegrass (Poa compressa), bulbous bluegrass (P. bulbosa), yellow sweetclover (Melilotus officinalis), Russian wildrye (Elymus junceus), Canada wildrye (E. canadensis), and orchardgrass (Dactylis glomerata). The top forage production on the lower pine zone range lands by the best grasses has been around 600 pounds of air-dry forage per acre.

Within the drier parts of the pine zone, grasses are needed which can compete with cheatgrass and annual forbs and which can lengthen the green feed period in the spring and early summer. The six grasses, listed above as being best, all fulfill these needs. They have effectively retarded re-encroachment by weedy plants and they maintain vegetative growth longer than do the abundant cheatgrass and annual forbs on depleted and non-reseeded range lands. Intermediate wheatgrass and pubescent wheatgrass have been particularly effective in lengthening the green growth period. While cheatgrass is commonly tinder dry on the lower pine zone grassland areas by the middle of May, intermediate and pubescent wheatgrass remain green well into July.

The nurseries continue to produce worth-while information on species adaptability and characteristics. At the Swauk Meadow Nursery in central Washington the adaptability of 143 accessions of 75 species of grasses, legumes, and browse to range lands within the lower ponderosa pine belt has been tested. The accessions under test have been catalogued into the use groups of Hafenrichter, Mullen, and Brown[1] for analysis. This system groups plants which reflect a use or a common quality affecting use for soil and water conservation. The analysis showed distinct differences in adaptability within most of the groups,

1/ Hafenrichter, A. L., Mullen, L. A., and Brown, R. L. Grasses and legumes for soil conservation in the Pacific Northwest. U. S. Dept. Agric. Misc. Pub. 678, 56 pp., illus. 1949.

reaffirming the need for adaptability testing of individual species and accessions of species rather than randomly choosing any one of a particular group. For example, within the rapid-developing, short-lived group of grasses, ratings from excellent to failure appeared. Among those species rating excellent were timothy (Phleum pratense) five accession, slender wheatgrass (Agropyron trachycaulum) P-1711, bearded wheatgrass (A. subsecundum), and Tualatin tall oatgrass (Arrhenatherum elatius). Examples of failures include slender wheatgrass (A. trachycaulum) P-3124, mountain bromegrass (Bromus marginatus) P-9982, and timothy (P-6860).

For the nursery site and the zone of test which it represents, four of the groups represented in the following table have given the highest general degrees of success. These are the wet-meadowland grasses; rapid-developing, short-lived grasses; late-maturing grasses; and the rapid-developing, long-lived grasses. The degree of success shown by legumes is not a true adaptation picture, for rodents have been the direct cause of failure of many legumes.

Classification of Accessions Under Test on the Swauk Meadow Nursery by Use Group, With Number of Successful Accessions

Use group	Number of accessions under test in 1950	Number of accessions rating good or better in 1950
1. Rapid-developing, short-lived grasses	29	19
2. Rapid-developing, long-lived grasses	19	12
3. Late-maturing grasses	11	7
4. Drought-tolerant, long-lived bunchgrasses	10	5
5. Drought-tolerant, long-lived sod grasses	3	1
6. Vernal-dominant, dryland grasses	10	3
7. Understory grasses with heavy root production	11	4
8. Wet-meadowland grasses	19	14
9. Sand-stilling grasses	3	0
10. Legumes	25	3
11. Miscellaneous (*Sanguisorba minor*)	1	0
Total,	143	69

At the Campbell Flat Nursery on the Starkey Experimental Forest and Range in northeastern Oregon the seedings are just now becoming old enough to begin to show species adaptability. This nursery is on good soil within the ponderosa pine zone. Since the first plantings were made in the fall of 1948 a total of 89 species and strains have been planted in three blocks, a total of 267 plots. Of these 267 plantings, 29 percent were rated good or excellent in 1950, 22 percent fair or poor, 34 percent very poor, and 15 percent as failures. These plantings were then in their second growing season. Those species which appear to be well adapted to the conditions found in this nursery, classified by use group, are as follows:

Rapid-developing, short-lived grasses:

Agropyron caninum	Awned wheatgrass
Agropyron subsecundum	Bearded wheatgrass
Agropyron trachycaulum	Slender wheatgrass
Arrhenatherum elatius	Tall oatgrass (Tualatin)
Bromus marginatus	Mountain bromegrass
Phleum pratense	Timothy
Poa bulbosa	Bulbous bluegrass

Rapid-developing, long-lived grasses:

Bromus erectus	Meadow bromegrass
Bromus inermis	Smooth bromegrass
Dactylis glomerata	Orchardgrass

Late-maturing grasses:

Agropyron amurense	---
Agropyron intermedium	Intermediate wheatgrass
Agropyron trichophorum	Pubescent wheatgrass

Drought-tolerant, long-lived sod grasses:

Agropyron repens	Quackgrass

Understory grasses with heavy root production:

Festuca ovina duriuscula	Hard fescue

Wet meadowland grasses:

Alopecurus arundinaceus	Highland foxtail
Alopecurus pratensis	Meadow foxtail

Legumes:

Lotus corniculatus	Birdsfoot trefoil
Medicago sativa	Ladak alfalfa

It has been very difficult to grow grass on the scabby ridge tops as found in the Ray Creek Ridge Nursery. Because the soil is thin and underlain by rock, the principal problems are early drought and frost heaving. Sometimes seedlings will emerge only to be heaved out of the ground by late fall or early spring frosts. However, timothy, pubescent wheatgrass, and intermediate wheatgrass continue to show promise, particularly on the hummocks where there is slightly more soil. No timothy seeding has been a complete failure. Other outlying plantings made on similar but less severe sites than Ray Creek Ridge nursery have shown success with slender wheatgrass, orchardgrass, and tall meadow oatgrass in addition to those listed above.

Ester of 2,4-D may prove effective in killing California false-hellebore. In a cooperative study with Washington State College, a 50 percent reduction in density of California falsehellebore (Veratrum californicum) was found one year following spraying with isopropyl ester of 2,4-D at the rate of 4 pounds per acre. At the time of spraying, the falsehellebore was 18- to 30-inches tall with no inflorescences showing.

Ester of 2,4-D at the rate of 2 pounds per acre, polybor chlorate at rates of 1 and 2 pounds per square rod, and polybor at 2 pounds per square rod reduced the density of falsehellebore from 14 to 19 percent. Polybor at the rate of 1 pound per square rod had no effect on the density of falsehellebore.

Effect of Pocket Gophers on Reseeded Stands

Over a two-year period, pocket gophers have caused a difference of about 6 percent in the basal area of crested wheatgrass plants in a 10-year-old stand. Observations were made of old established plants within the drill rows and of new plants which have become established between the rows. New plants became established at a much more rapid rate on the plots where gophers were controlled than on the uncontrolled plots. One of the plots where gophers were not controlled actually suffered a loss of 10 percent of the old plants, but on the other plots there was no change in basal area. It appears that if gopher control is economical at all, it should be done consistently every few years to protect the old stand and to permit new plants to keep up the stand. As indicated last year, a method of deep plowing to eliminate the food supply of the gophers at planting time may largely solve the problem.

Effects of Logging Studies

Recovery of ponderosa pine range is incomplete four years after logging. Vegetation on the logged-over ranges on which the permanent transects were located has continued to improve. Total vegetation on one transect is now 22 percent greater than it was prior to logging, but on another transect the cover is still 29 percent less. On the one transect, weeds have accounted for the great increase since they are now nearly twice as dense as they were prior to logging. Grasses are still 27 percent below the original density and shrubs are 12 percent less. On the second transect, weeds have reached the same level they had prior to logging but grasses are only about half as much and shrubs are 23 percent less than they were prior to logging. A lower quality class of vegetation continues to dominate the vegetation following logging.

Cheatgrass, St. Johnswort, and other undesirables are invading logging disturbed ranges. Where prior to logging there was very little cheatgrass or St. Johnswort, they are beginning to make up a sizable part of the stand. On one transect, cheatgrass now makes up 9.7 percent of the total vegetative density. This re-emphasizes the need for a reduction of damage done by logging and for the artificial re-establishment of desirable vegetation to fill in the areas left denuded.

Big Game-Livestock Relationships

Big game are an increasing problem on forest ranges in the Pacific Northwest as herds increase, and browse and other feed supplies diminish. The demand for more game is also increasing, so ways must be devised for obtaining better management of the herds and the ranges upon which they depend. First of all, game herds must be accounted for in estimates of grazing capacity, so it is necessary to know the forage requirements of big game. Secondly, we need more information on the palatability of game forage plants and need to develop proper use factors or utilization standards for those species.

An attempt at developing utilization standards for a few browse species was made by clipping antelope bitterbrush, rubber rabbitbrush (Chrysothamnus nauseosus), and snowbrush (Cercocarpus ledifolius) and creambush rockspirea (Holodiscus discolor) at five intensities. Although there is great fluctuation in the herbage production of these species from year to year, yields appear to be highest when about 50 percent of snowbrush and bitterbrush plants is clipped, and when 75 percent of rubber rabbitbrush is clipped. Average twig lengths of these species have changed little under treatment. However, with creambush rockspirea both yields and twig lengths have increased steadily under the 95 percent clipping treatment. These results, however, should be considered only tentative, because further analysis of some of the data show that many more plants than were used in this study are needed for statistically reliable results. Although numbers of plants required will vary with the sites, the following are indicative.

	No. of plants per treatment	No. of twigs per treatment
	Needed to measure variability in change	
Rubber rabbitbrush	65	83
Antelope bitterbrush	40	400
Snowbrush	80	140
Whortleberry	25	220

Plans for 1952

So far as the grazing management research is concerned, it is planned during 1952 to complete the development of the physical plant on the Starkey Experimental Forest and Range. A new cross fence, made necessary by the construction of the two sets of pasture fences, is being planned for the allotment. The corrals and water developments are to be completed, and the stock scales installed. The north unit of pastures will be grazed in another year of calibration. Only a part of the south unit of pastures will be grazed. The clusters and plots for sampling the north unit of pastures will be installed.

Standards of range condition and trend which have been tentatively set up for the several subtypes will be refined and tested in several parts of the region, and methods of measuring condition and trend on the Starkey will be coordinated with the other range management research there. Emphasis will be given to developing a method for the more effective measurement of floristic composition in connection with the line transect. Investigations on the condition and trend of ponderosa pine ranges will be continued.

In reseeding research, it is hoped that some new studies will be started to develop effective methods for seeding scab ridges, to probe somewhat into the problems of seeding browse species, and to get additional information on reseeding of logged-over pine range. It is intended that the reseeding position now vacant in eastern Oregon will be filled so the reseeding work here can be revitalized. Analysis of data from completed studies will be continued and final reports or publications prepared.

Field work on big game-livestock relationships and the resistance to clipping of important browse species will continue on a much reduced scale pending completion of the analysis of data and the preparation of reports.

Remeasurement of the permanent transects in the effects of logging studies will be made. Data will be collected on ponderosa pine range from which can be calculated a regression of reductions in grazing capacity on degree of logging disturbance.

Plans for 1952 include completion of the following publications and reports.

1. An article describing the requirements for designing a study of clipping intensities of important browse plants will be prepared for publication in the Journal of Wildlife Management.

2. An article describing the effects of different intensities of clipping on important browse species, and the fluctuation of production, twig length, and flowering ability with clipping and variations in weather will be prepared for publication.

3. Utilization and range survey results covering the past 10 years on the Starkey Experimental Forest and Range will be prepared for publication.

4. Data on reseeding at present appearing in the Region 6 Range Reseeding Handbook will be revised, brought up to date, and prepared as a cooperative State publication or as a Department-rank publication.

5. Conclusions on the effects of logging and the methods for reducing competition by cheatgrass will be prepared for popular publication in the Washington and Oregon Farmer magazines.

6. The Station research note on reseeding logged areas will be revised in the light of present knowledge and prepared for publication.

7. Results on reduction of falsehellebore by chemical treatment will be prepared for publication cooperatively with Dr. Rasmussen of Washington State College.

FOREST MANAGEMENT RESEARCH

The year 1951 was marked by numerous changes in Forest Management personnel. After heading the Division for five years, Briegleb left in August to become Director of the Central States Station. Matson, who had guided applied management studies since 1946, left the Division in mid-year to head up the Station's utilization work. Soil Specialist Tarrant continued on military leave with the U. S. Navy. Johnson rejoined the Portland staff in July as mensuration project leader and Meagher took up his new duties as Division Chief late in November.

James returned to the Port Orford Cedar Experimental Forest in October after a tour of duty with the Army in Korea. Three of the men on the other research centers and experimental forests--Dahms, Staebler, and Stein--were on educational leave a substantial part of the year.

Despite these interruptions, active research was carried on at the 10 existing experimental forests and a new experimental forest--the South Umpqua--was formally established July 6. This new field laboratory, which will be operated in cooperation with the Umpqua National Forest, is representative of the mixed conifer stands of southwest Oregon. It is located in the broad transition zone where the Douglas-fir types of Oregon merge with the California pine forests. Douglas-fir, ponderosa pine, and sugar pine along with other conifers form a complex and highly variable mixture that presents a number of perplexing timber harvesting and regeneration problems.

Another highlight of the year's activities was the formation in December of an advisory committee for the Puget Sound Research Center. This group, composed of a dozen foresters with broad experience in Federal, State, and private forestry, will meet with the research center staff several times a year. Major aims will be to promote closer cooperation and coordination of Federal and non-Federal forest research programs. They will also explore means for expediting the dissemination and application of research results.

Progress during 1951 in the continued development of the Station's 11 experimental forests was in no small measure due to the interest and active cooperation of the national forests or private companies that administer or own the lands involved. Seven experimental forests--Blue River, Cascade Head, John Day, Port Orford Cedar, Pringle Falls, South Umpqua, and Wind River--are on national forests. Voight Creek is on

lands of the St. Paul & Tacoma Lumber Company, McCleary on lands of the Simpson Logging Company, Hood Canal on lands of Pope and Talbot, Inc., and Hemlock on St. Regis Pulp and Paper Company lands. At Cascade Head the orderly progress of harvest cutting trials was assured through a new cooperative agreement with the Publishers' Paper Company.

Major accomplishments during 1951 and plans for 1952 are summarized in the following paragraphs.

Young-Growth Management in the Douglas-fir Region

Since 1947, the management of second-growth stands in western Oregon and western Washington has been given major research attention under the guidance of the Second-Growth Management Committee. Continued interest in this field of work is illustrated by the widespread use made of a 1950 booklet, "Your Trees - A Crop." This nontechnical handbook on second-growth management was prepared by the committee and published in 1950 through the joint financial assistance of the State forestry departments and State forest schools in Oregon and Washington. Even though 20,000 copies were run in the first printing, the supply has been completely exhausted and plans for a second printing of an additional 20,000 copies are now under way.

Several different methods of making thinnings or intermediate harvest cuttings are being tested on a commercial basis in various parts of the region. Douglas-fir stands under study vary from 26 to 110 years in age and from II to IV in site quality.

At Voight Creek, experience during 1951 demonstrated that light thinning for 8-foot sawlogs can be carried out in a 45-year, site III Douglas-fir stand at a cost of $30 per thousand board feet. This leaves $4 to $8 per thousand board feet for stumpage. In this case logging was done by a 5- to 10-man crew and logs were skidded by horses to a maximum distance of 600 feet. Costs of horse skidding varied from $8 per M b.m. for 100-foot distances to $20 per M b.m. for 800-foot distances. Only logs 8 inches or larger in diameter proved to be capable of repaying production costs. For well-stocked stands of Douglas-fir on sites II and III in the Puget Sound area, it was again demonstrated that receipts from light thinnings (10 to 15 percent) will finance an adequate road system if the stand has reached an age of at least 45 years.

Growth measurements on plots thinned three years ago at Voight Creek show that as much as 41 percent of the cubic-foot volume in well-stocked Douglas-fir stands can be removed without appreciably reducing growth.

The program of light commercial thinnings in 50-year-old, site II Douglas-fir was continued on the McCleary Experimental Forest with 10 percent of the volume removed on an additional 45 acres. About one-fourth of the 1951 cut consisted of trees windthrown the previous winter, illustrating the value of a forest geared to light frequent

cuts and capable of quick salvage operations. The third annual cut was completed on the "Farm Forestry 40."

Stands on the Hood Canal Experimental Forest are representative of the medium to poor sites in the Puget Sound area. Commercial thinnings taking out about 16 percent of the volume in site III, 60-year-old Douglas-fir have been under way for two years.

At Wind River, the first commercial thinning was made in 1938 in a 100-year-old stand of site III Douglas-fir. At that time 7,800 board feet per acre were removed in the form of piling. An annual growth rate of about 600 board feet per acre has been maintained during the 13 years since the first thinning, and windfall losses have been negligible. By 1951, the volume removed in the first cut had been entirely replaced through growth and a second thinning was carried out. This time about the same volume was removed but sawlogs were the main product. Intermediate harvest cuttings will be continued in this stand as long as an annual growth rate of at least 500 board feet per acre is maintained. When growth drops below this figure, a clear-cut harvest is anticipated.

Management of young-growth spruce-hemlock forests of the coastal zone is under study in two areas--the Cascade Head Experimental Forest in Oregon and the Hemlock Experimental Forest in the Grays Harbor portion of Washington.

A preliminary cutting in 1950 removed the scattered old-growth trees over most of the Hemlock Experimental Forest. This leaves a thrifty 50-year-old stand of almost pure hemlock. During 1951, marking was completed for a study of two methods of thinning--from above and from below--and two degrees of thinning--heavy and light. In the light thinning, a volume equivalent to three years' growth will be taken out. The heavy thinning will remove the equivalent of six years' growth.

At Cascade Head, large-scale experimental cuttings are under way in a 100-year-old site II stand of mixed spruce and hemlock. During 1951, a new 79-acre unit was added to the series of intermediate harvest cuttings. In this area a combination of tractors and horses is under trial for yarding. On portions of the Cascade Head area too steep and rugged for partial cutting, the major project continues to be an evaluation of the staggered-setting system for harvest cuts in the young-growth spruce-hemlock. Thirteen settings totaling 276 acres have now been clear cut. They range in size from 2 to 81 acres and provide areas of various sizes and shapes where basic seed fall, regeneration, windfall, erosion, and slash burning studies are being installed.

Old-Growth Management in the Douglas-fir Region

For over 40 years Wind River has been the site of many of the basic silvicultural studies for Douglas-fir.

Recent records for the Wind River Natural Area illustrate the extreme variability that may be expected from year to year in mortality losses in virgin stands. During the two-year period, 1947-49, annual losses averaged 221 board feet per acre. In the following two years, 1949-51, mortality increased to 779 board feet per acre per year, a figure almost four times the previous level. In an adjacent old-growth stand, partially cut two years ago, windfall losses have consistently varied with the proportion of the stand removed. Under 15 percent removal, losses have been light. In contrast where 40 percent of the stand was cut, losses have been exceedingly heavy. A summary report on partial cutting in old-growth Douglas-fir is in preparation. This will include data from study areas in many parts of the region, including those at Wind River.

Since 1949, research effort in old-growth Douglas-fir management has been concentrated largely on the Blue River Experimental Forest, which represents the steep, poorly accessible watersheds where most of the remaining old-growth Douglas-fir is located. In cooperation with the Willamette National Forest, Blue River is being developed to determine how silvicultural, engineering, economic, protection, and watershed needs can best be coordinated in planning and carrying out the orderly conversion of a virgin-forest watershed.

Since topography is rough, high-lead logging will be employed on most of the area following a system of clear-cutting by staggered settings. Of first importance is the location of roads, landings, and cutting boundaries for both the cut and leave settings. Decisions must be based upon a detailed knowledge of the terrain and stand conditions and must weigh and balance factors such as logging costs, road costs, distribution of age classes, overmaturity, brush development, and the probability of major loss from windfall or fire.

In the two years since Blue River was activated, sales totaling 40 million board feet have been made and the roads have been extended through about half the drainage. In another four years the initial road system will be essentially complete.

Relative costs of doing the sale-layout job have been measured in terms of both man-days per acre and per thousand board feet. During 1951 a comparison was made between a sale layout based on a topographic map prepared from air photos and a layout based on a map prepared solely by ground crews. Although the two sales were not comparable in all details, the study showed a slight advantage for the air photo map. Improvement stemmed from a reduction in time required for ground reconnaissance when the more accurate air photo map was used.

A study of the basic principles involved in planning an efficient system of permanent truck roads for high-lead logging in rough topography was initiated in 1951. Tentative guides are:

1. Where topography permits, spacing between roads should approach twice the economic yarding distance. Closer spacing is inefficient since the landings compete for the same timber.

2. Between landings on the same general level, a road should follow the most direct route on a near level or gentle, favorable grade.

3. Climbing roads between levels should generally follow the most gentle topography and the number should be reduced to a minimum.

4. Number of road levels needed in a given drainage varies with each major change in topography. If the range in elevation remains constant, more levels are required on gentle than steep slopes. Thus, in moving up a drainage, new road levels must be added if the topography changes from steep to gentle. In contrast, some road levels must be terminated if topography changes from gentle to steep.

These more or less theoretical principles will be tested in 1952 in planning the road system for the north side of the Lookout Creek drainage.

Another innovation at Blue River this past year was the pioneering of the road right-of-way with a bulldozer before the right-of-way timber is felled. A narrow tractor trail is first constructed along the top of the cut. Trees felled for this trail are held to a minimum. Culverts are installed and fills partially completed during the pioneering. The timber is then felled and yarded and road construction completed. Felling and bucking is simplified because men and equipment can be transported on the cat trail and less breakage is encountered along partially filled canyons. Yarding is speeded up since the bulldozer operates from a level position and the logs are seldom covered by dirt and rocks. Culvert installation is also less time consuming because little debris is usually present in the stream bottoms before felling. Under present practices felled timber on the right-of-way often presents a serious obstacle when the first cut is made by the bulldozer. This is especially true on steep slopes. Use of the pioneer right-of-way trail has minimized this difficulty and is now standard practice on the experimental forest.

During the harvesting program at Blue River, detailed records have been taken on logging costs to furnish guides for improving the layout of sales. In addition, several detailed studies are under way in selected cutting units on regeneration, brush control, and watershed management. A study on Poria weirii has been started in cooperation with the Office of Forest Pathology, and the Oregon Cooperative Wildlife Research Unit began fish and game studies this year.

Principal activity on the Port Orford Cedar Experimental Forest was the completion of a 4 million board-foot sale. On 20 acres, about one-third of the volume in a dense 160-year stand of mixed Douglas-fir and cedar was removed in a partial cutting. On the remaining 40 acres,

scattered veterans were removed from a stand predominantly a mixture of 40- to 50-year-old Douglas-fir and cedar. Sample plots will be established in the partial cutting to assess logging damage, windthrow, growth, and reproduction. Part of the 40-50 year stand will be treated to increase the proportion of cedar. Nine lightning fires during 1951 resulted in a partial kill of the timber over several hundred acres. A salvage sale is planned for 1952.

Inventory work on the new 4,500-acre South Umpqua Experimental Forest was started in July. Stand conditions are extremely variable in the South Umpqua drainage and development of cutting methods that will meet the requirements of these stands will be a primary objective. Condition class mapping, as developed in California for "Unit Area Control," offers one promising approach and 480 acres were mapped on this scheme. Condition classes were based on age, stocking, and species composition. The overstory and understory were classified separately. Additional information was also recorded on percent of sugar pine, frequency of blister rust infection, adequacy of pine seed trees, numbers of salvageable snags and windfalls and degree of brush threat. These stand descriptions will be tested as a practical guide for gearing cutting and improvement practices to the needs of each major condition class.

Ponderosa Pine Management

Timber-growing studies for the forests that occur east of the Cascade summit in Oregon and Washington are conducted by the Station's Deschutes Research Center at Bend, Oreg. Attention is focused on problems of the ponderosa pine type, with research concentrated on the Pringle Falls Experimental Forest near La Pine and the John Day Experimental Forest near La Grande.

At Pringle Falls, some 3,020 acres of almost pure virgin pine were covered by a light sanitation-salvage cutting in 1950. Main objectives were to remove dying and declining trees that present a high risk from bark beetle attack and to extend the system of main utilization roads and logging spurs over the entire area. Altogether about 5 million board feet were harvested and construction was completed on 19.2 miles of utilization and spur roads. An average of 1.2 high risk ponderosa pine trees were removed per acre, representing only 9 percent of the pine volume. By effectively reducing mortality losses, this initial light cut should increase annual net growth by about 40 board feet per acre for a period of at least 10 years. At present stumpage rates, this increase in growth has a value of about $1.07 per acre yearly. A detailed account of the cutting was released late in 1951 as Research Paper No. 2, "A Sanitation-Salvage Cutting in Ponderosa Pine," by Sowder. In treating stands that contain substantial numbers of high-risk trees, light cuttings of this type are a logical first step in the over-all job of conversion.

Test cuttings were continued on the John Day Experimental Forest to compare a 60 percent harvest cut using current cutting practice with

a 40 percent sanitation-improvement cutting. In the lighter cutting emphasis is given to the removal of trees of poor thrift, improvement of spacing in groups and to increasing the proportion of pine in the reserve stand. During 1951, permanent sample plots were established in portions of the sale where logging had been completed.

Growth on seven large method-of-cutting plots at Pringle Falls was analyzed during 1951. In this study from 20 to 80 percent of the original volume had been removed in the 1936 harvest cutting. Reserve-stand volume varied from 2,900 to 16,700 board feet per acre. Average annual mortality over the 11-year period (1936-47) ranged from 6 to 15 board feet per acre among the various treatments.

For the same period annual net growth varied from 44 to 92 board feet per acre. In general the heaviest reserve volumes made the best growth and the light reserves the poorest, but the relationship is far from consistent. Apparently variations in the condition, thrift, and stocking of the original stand have affected growth rate and mortality to a greater extent than intensity of cutting or type of marking.

Current results from studies on planting, seeding, thinning, or pruning in ponderosa pine are included in the sections of this report on "Regeneration" and "Stand Improvement."

Regeneration Studies - Natural and Artificial

Interest in forest regeneration continues to increase and definite progress is being made in the successful restocking of recent cutovers by either artificial or natural means. For the older nonstocked burns and cutovers in the region, the picture is not so bright. These are receiving less attention because rehabilitation costs are high and because the poor stocking is in many cases obscured by a cover of alder, brush, and scattered, poorly formed conifers.

In the pine region, more study is needed to find ways to restock the extensive brush areas and to encourage the establishment of new seedlings on the partial cuttings where reproduction is sparse or lacking entirely.

Natural regeneration. During 1951 seed fall studies using seed traps were continued at Voight Creek, Wind River, Port Orford Cedar, and Cascade Head Experimental Forests in the Douglas-fir region, and on the Fremont National Forest in the ponderosa pine region. Early results indicate that thinning stimulates seed production in young Douglas-fir. These studies also demonstrate that period of seed fall varies widely among both years and species and even between short distances within the same locality. At Cascade Head one area showed 90 percent seed fall by November 1; on a second area, less than two miles away and at a similar elevation, only 11 percent of the seed had fallen. Evidently a careful check is necessary to correlate seed fall with the slash burning program.

For ponderosa pine, studies have demonstrated that even heavy seed fall does not assure natural regeneration unless there is adequate rodent control, a good seedbed, and a favorable season or two for survival.

The use of rodent baiting to conserve natural seed fall on cutover areas was given special attention during 1951 because there was a satisfactory seed crop of several species. In cooperation with the Fish and Wildlife Service, paired areas--one baited and one not baited--were established on the Wind River Experimental Forest and in the Puget Sound and Siskiyou-Cascade Research provinces. Parallel tests were conducted in a number of widely scattered locations. Rodent populations were sampled this year and the areas will be checked for natural restocking in the spring.

In staggered setting harvests, the relationship of size of clear-cut area to the rate of natural restocking is under study. Restocking on large cutovers was found to be similar to that on smaller areas up to a distance of about 500 feet from the edge of green timber. Beyond that point it was progressively poorer. Regeneration was best on surfaces disturbed by logging but seedlings did not develop on heavily used, hard-packed tractor roads.

Natural restocking on burned and unburned surfaces is being compared on some 60 pairs of plots throughout the region; progress on that project is reported under "Fire Studies."

Artificial regeneration. The irregular occurrence of medium or heavy seed crops makes it necessary to store large quantities of tree seed for a number of years to assure adequate supplies for nursery and direct seeding operations. A cooperative study with the Boyce Thompson Institute has been in progress for six years to determine the best storage temperature. These tests will be continued four years more. So far, they demonstrate that seeds of all important Northwest species can be stored for at least six years without loss of viability if held at temperatures of freezing or lower.

While the mechanics of broadcast seeding by helicopter and hand seeder have been satisfactorily worked out, many of the rodent control and seedbed problems remain unsolved. Studies in cooperation with the Fish and Wildlife Service, the States of Oregon and Washington, and private agencies were continued during the year to test new rodent baits, rodent repellents, and methods of application. Several candidate materials were tested at Wind River to determine if they could be applied directly to the seed without reducing viability. A compound known as "tetramine," which showed the most promise, has been given extensive field trials but results will not be known until germination is over in the spring.

Last year, as part of a large-scale seeding project (600 acres) on a severe site of the Gifford Pinchot National Forest, different rates of seeding varying from 1/4 to 2 pounds of Douglas-fir seed per acre

were tested. At the end of the second growing season stocking was found to be irregular and averaged less than 300 seedlings per acre even on the two pound sowing. Similar second year results were recorded on Henderson Creek where a 20-acre patch was seeded at the rate of one pound per acre.

The hand planter built last year to plant single, pelleted seeds has been reworked to eliminate certain weaknesses. A working model is now in use and is being redesigned to handle bare seed of the larger seeded species.

Another new device, the "Keyes screen," is being tested in southwestern and eastern Oregon to protect pine seed from rodents and to further protect seedling roots from cutworms. It consists of a screen cylinder containing a seed packed in a core of soil. It is set so that the screen will extend about 2½ inches below the surface and an equal distance above. Early tests show promise at least for sugar pine.

Problems continue to arise in connection with planting stock and survival. For several years both pine and fir seedlings have reached the planters with the roots partly dead from an unknown cause. Stock at an Oakridge planting site in 1951 had roots dead 1-3/4 inches back from the tip. A check lot was ordered and paired seedlings were planted side by side. Roots were dead on the check stock for 3/4 inch from the root tip. Even though affected, the control stock made a first year survival of 62 percent as compared with 30 percent for the original stock; there was also a comparable difference in height growth. Follow-up studies are planned to help determine the cause of injury.

Natural regeneration studies of Port Orford white-cedar show that cedar and its associates will gradually restock under a wide variety of conditions if there is an adequate seed source and if fires are kept out. Seed source was found to be the most critical factor. To encourage prompt reseeding of this species, openings not more than 10 chains across are recommended. Older cutting operations usually high-graded the stands for cedar and reduced both the percent of cedar and the available seed source. Clear-cut areas on the Port Orford Cedar Experimental Forest will provide burned and unburned surfaces for future observation and study of the development of both pure and mixed stands of Port Orford cedar.

Stand Improvement

Liberation cuttings and plantation release. On some areas in both fir and pine, brush development following cutting is so rapid that natural reproduction cannot get started before the brush takes over. On several experimental forests, selected "brush-threat" areas are mapped and planted promptly after cutting, leaving unplanted areas as a check. Trials for the coast country at Cascade Head and on the Blodgett area are in their second and fifth years.

In older plantations on the Siuslaw National Forest, cooperative studies are under way to release planted trees that are being choked out by rapid-growing but worthless alder by slashing, girdling, and poisoning. Where alder is young, helicopter spraying with 2,4-D and 2,4,5-T gave the most promise for plantation release. In the spring of 1952 the areas will be examined in order to determine comparative effectiveness of the different treatments.

Thinning. Since individual trees in young Douglas-fir stands usually assert their dominance early and approach maximum height growth regardless of stand density, few pre-merchantable thinnings have been studied. One exception during 1951 was the thinning of a 5-acre tract within a dense 26-year-old Douglas-fir plantation at Snow Creek on the Olympic National Forest. About 5 cords of pulpwood, representing 13 percent of the stand volume, were cut and 80 selected crop trees pruned per acre. Receipts from the sale of pulpwood paid for only a part of the stand improvement operation. Prior to thinning, this 26-year-old 8 x 8 planting displayed only 65 percent of normal yield table stocking in terms of number of trees, but 140 percent of normal stocking according to basal area.

In the pine region, regeneration tends to occur in dense patchwise fashion and release thinnings are more urgently needed to prevent stand stagnation. Installation of an 80-acre thinning study, in cooperation with the Deschutes National Forest was completed during 1951. Factors under study in this dense young stand include degree of release, spacing of crop trees, and influence of overwood. Analysis of records from older studies in several parts of the pine region show that diameter growth can be almost doubled through pre-merchantable thinnings. There is some indication that height growth may also be improved.

Pruning. Publication last year of a handbook, "Financial Aspects of Pruning," and two trade journal articles this year, "Shall We Prune to Provide Peeler Logs for the Future," and "Healing Time for Pruned Douglas-fir," aroused interest and paved the way for further work in this field.

A 14-year report of differential live-crown removal in a 28-year-old stand of Douglas-fir showed that the lower quarter of the live crown can be safely removed without damage by sunscald or reduction in diameter and height growth. In contrast, the removal of one-half or more of the live crown proved detrimental. There was no evidence of decay entrance through pruning wounds.

Cost studies at Voight Creek demonstrate that the crop trees can be pruned to a height of 18 feet in a 40-year-old stand of Douglas-fir for about 25 cents per tree.

In the young sugar pine stands of southwest Oregon, there are good opportunities for strengthening blister rust control through the pruning of selected crop trees. Most infections occur low in the crown,

and they can be eliminated by pruning if the infection has not reached the main trunk of the tree. Pruning tests on the South Umpqua will be started in 1952.

Forest Soils

Active field work on forest soils has been almost at a standstill because of Tarrant's tour of duty with the Navy. Carmean completed the field sampling during 1950 on a cooperative study of "soil-site relationships" with Duke University. Soil samples and data were analyzed early in 1951 and a manuscript, "Physical Characteristics of Four Forest Soils of the Douglas-fir Region of Southwestern Washington," prepared. Factors showing a close relationship to site index are: (1) effective rooting depth, (2) content of gravel, (3) available content of capillary moisture, and (4) relation of capillary to non-capillary pore space.

A cooperative report, "Observations on Litter Fall and Foliage Nutrient Content of Some Pacific Northwest Tree Species," was published in the December issue of the Journal of Forestry. The study shows the nitrogen, potassium, phosphorus, calcium, and magnesium content of the annual needle and leaf fall of important Northwest trees. Western redcedar tops the list in total plant nutrient (64 lbs. per acre), even surpassing alder and bigleaf maple. The pines were significantly low. The findings indicate that species given little attention in the past may be important in the ecology of our types.

Forest Mensuration

Mensuration activities during the year were threefold:

1. Assistance to divisions within the Station in growth estimation, sampling, and experimental design.

2. Assistance to outside agencies in planning surveys and methods of data analysis.

3. Mensuration projects.

Under the first category, cooperation with Forest Survey deserves first mention. New techniques for estimating growth were developed and applied to both the Southwestern Oregon Survey Unit and to Cowlitz, Skamania, and Wahkiakum Counties in southwestern Washington.

A system of double sampling for estimating timber volume on large areas through the combined use of field and photo volume plots was also developed. This system is being used in southwestern Washington and has helped to reduce survey costs without sacrificing accuracy.

Another job of increasing importance is in the field of experimental design. Assistance this year was given in the design for a major range management study on the Starkey Experimental Range and in the

design of a number of thinning and seeding experiments at the experimental forests.

Outside assistance was given the State Forester's office in Oregon on a survey plan for State-owned lands in Clatsop County. Help was also extended to the Office of Forest Pathology on the analysis of data from a decay study for western hemlock, and to the Bureau of Entomology and Plant Quarantine in the design and analysis of forest insect control surveys.

Four mensuration projects were carried forward or completed in 1951. A study of stocking was summarized in the article "An Approach to Density Measurement in Douglas-fir" by Briegleb. Following review, this was submitted to the Journal of Forestry for publication. The revision of the hemlock yield tables was completed by Dr. George H. Barnes and this new information is currently being readied for departmental publication. In addition to the conventional yield tables, this bulletin will include a set based on average stand diameter.

The remeasurement and analysis of the Station's permanent growth plots is a recurrent task. A set of seven plots representing young even-aged Douglas-fir on the Siuslaw National Forest were remeasured in September. They showed an average annual growth of 1,223 board feet per acre (Scribner rule) during the past five years. Except for two plots that suffered abnormal mortality some ten years ago, the trends of volume over age are remarkably linear.

An analysis of mortality was also completed for the 100-year-old spruce-hemlock stands at Cascade Head. Mortality averaged some 538 board feet per acre yearly during the five years 1945-50. This represents a slight increase over previous periods but the stands are still vigorous and well stocked.

A new project in 1951 was the development of a set of volume tables for lodgepole pine. These are based on tree measurements taken on the Ochoco National Forest in Oregon and on the Chelan National Forest and Colville Indian Reservation in Washington.

Fire Studies

The 1951 fire weather in western Oregon was the most severe of the last 20 years in terms of dangerous combinations of drought, relative humidity, and wind speed. This was revealed by fire weather indices devised and tested during the year. Ratings of this type are needed to more accurately compare the success and weakness of the fire prevention and suppression measures used in different years. Number of man-caused fires was formerly the only available indicator of the value of various prevention tools such as radio, press, poster, personal contact, law enforcement, forest closures, and hazard reduction. Total acres burned and average size of fire have been used more recently to measure the value of suppression measures. Yet number of fires, acres

burned, and average size of fire depend in turn on the severity of fire weather which varies greatly from year to year. The new fire weather indices along with numbers and acreages of fires now offer a possible means for judging prevention and suppression success.

These new indices are computed from rainfall, wind speed, and relative humidity records. Average or total values are compiled for three portions of the fire season (April 1 to October 31) and for various combinations of these periods. Rainfall records are used to show: (1) number of rainless days or days when fires are liable to spread; (2) average time between wetting rains (1/4-inch or more per day) or average length of time between significant recoveries of moisture under the surface layer of logs, snags, and duff. Wind speed and relative humidity measurements are combined to show the burning index for each day. Burning indices for the driest 25 days in each period are then averaged.

Fire behavior. Behavior records including rate of spread were made during 33 days of observation on 10 large fires in Oregon and Washington. With one possible exception, most of the spread resulted from wind-carried embers that started spot fires ahead of the main fire. As fuels became drier, volume of fuel greater, or wind stronger, rate of spread by spotting increased. Spot fires 1/4-mile ahead of the main fire were common and in a few cases spot fires suddenly appeared as far as two miles ahead of any other visible fire.

One fire, strangely enough, advanced steadily by progressively spotting some 500 feet ahead of the main fire on a day when the relative humidity did not drop below 52 percent and was above 60 percent when spotting was still frequent. In this case, wind speed was only 6 to 12 miles per hour. Fuels responsible for the spread included old logs, scattered snags, and other woody debris remaining after logging and burning about 20 years ago. Embers usually ignited in rotten wood present on the surface of logs, snags, stumps or in heaps on the ground.

Daily fire danger forecasts. In rugged topography wind speed and direction vary greatly from hour to hour and place to place. To determine the value of wind forecasts made a day in advance in rating fire danger, a test was begun in 1950 in cooperation with the fire weather service of the U. S. Weather Bureau in both Oregon and Washington. Twice daily the Weather Bureau prepared a forecast for each of 13 mountain-top stations representing full exposure to winds of the surrounding locality. Forest Service observers at these stations recorded the actual wind velocity and direction. Forecasts and actual wind measurements for the 1950 and 1951 seasons were then carefully analyzed. Since local topography and surface heating greatly distort the general wind flow in mountainous areas, the accuracy of the wind forecasts for specific points was not high enough to meet the needs of daily fire danger rating and fire control planning. The results, however, will help in the development of estimating methods that will be practicable and reliable.

Several methods for estimating burning index a day in advance were tested on six ranger districts during 1950. Analysis of these records in 1951 showed that weather forecasts when adjusted by a local correction factor could be used to estimate the next day's fuel moisture. When estimate of fuel moisture was in turn combined with average wind speed (based on previous records for a given station) the most accurate estimate of burning index was obtained. Field tests were repeated on the six ranger districts during the past fire season and these will be analyzed early in 1952 to provide a check for these tentative conclusions.

Slash problems of Douglas-fir region. The effects of broadcast burning are being studied on 61 pairs of 1/4- to 1/2-acre plots representing different portions of the Douglas-fir region. One plot of each pair is included in the regular slash fire of a logging unit while the other is left unburned. The paired plots in each case are adjacent to each other and were selected so that they represent the same aspect, slope, soil cover, distance to seed trees, and amount of slash. Fuel type, conifer-stocking, and amount and species of brush and weed cover are recorded annually. Ten of the pairs have now been studied for five years and twenty for three years.

For the 10 oldest tests, conifer-stocking was slightly better on the unburned than on the burned surfaces. Of the 20 pairs of plots with a 3-year record, 16 pairs showed more seedlings on the unburned plot, and 3 pairs showed more seedlings on the burned plot. The remaining pair of this series contained no seedlings. Many of the seedlings on the unburned plots were hemlock, cedar, or true fir that had come in before logging. Estimates of rate of spread and resistance to control show a greater fire hazard on the unburned than on the burned plots.

In the third growing season after burning, brush covered about 20 percent of the unburned surface and 5 percent of the burned surface. Herbaceous plants covered about 30 percent of the area under both treatments.

Plans for 1952

In all phases of forest management research, emphasis during 1952 will be directed toward the early completion of study installations already started at the research centers and experimental forests and to the analysis and reporting of field tests that have been finished.

For the applied management studies in Douglas-fir and spruce-hemlock, this will involve additional large-scale sales at Blue River, Cascade Head, and Wind River. Commercial thinnings will also be continued at the four cooperative experimental forests in the Puget Sound area and information already developed on costs and methods of thinning will be summarized and released. The long-overdue progress report on partial cutting in old-growth Douglas-fir will likewise be completed for publication. At the new South Umpqua Experimental Forest, a major job will be to prepare a research program for the mixed pine-fir forests of that area.

In regeneration, the number one task is the revision of Isaac's bulletin "Reproductive Habits of Douglas-fir." The first edition published through cooperation of the Pack Foundation is now out of print. New information developed during the past ten years will be incorporated into the revision. The results of a 1949 survey on the regeneration of Port Orford cedar in both partial- and clear-cuttings are now in manuscript form and will be released early in 1952. The Station will also participate in exploratory tests of a commercial product known as "Ultrawet." This chemical supposedly attracts and holds soil moisture and may be beneficial in seedling germination and survival on dry sites. In addition, another soil conditioning product known as "Or Zan" (Crown Zellerbach) will be given a trial.

In ponderosa pine management, effort will be concentrated on two research publications: (1) A summary of results from past thinnings in ponderosa pine, and (2) growth after partial cutting in ponderosa pine.

Plans for the mensuration section are to complete the form class volume tables for lodgepole pine and a summary report on all the permanent growth plots in Douglas-fir. Further effort will be given to improving the design for thinning experiments and to reviewing the manuscript of the revised hemlock yield report and forwarding it for publication.

In fire studies, reports will be prepared on both wild-fire and slash-fire behavior, on the relation of fire occurrence to fire danger, on advance estimates of burning index, on longevity of snags in snag patches, and on preliminary findings from the Douglas-fir slash study. Additional field data will be collected on the Douglas-fir slash study, on fire behavior, and on rating the severity of the fire season.

FOREST INSECT INVESTIGATIONS

(Bureau of Entomology and Plant Quarantine
in cooperation with Forest Service)

Forest Insect Survey

The 1951 survey of forest insect conditions in Oregon and Washington covered all of the timbered areas of these two States. A total of 221 flying hours was spent on the detection phases of the survey. Ground crews checked the aerial observations and recruised numerous permanent plots of various sizes and types in order to record the course of infestation of the more important species of insects. More than 100 individuals representing Federal, State, and private forestry interests participated in the survey to evaluate the spruce budworm situation. Through the cooperation of the Western Pine Association a greatly expanded ground survey program was undertaken in the pine region. The highlights of the region-wide survey findings and the progress on research and control are discussed by insect species, as follows:

Spruce Budworm

In 1951 some 927,000 acres were sprayed to control the spruce budworm in Oregon and Washington. This brings to 2,128,000 acres the total acreage that has been sprayed during the period 1949-51 at a cost of approximately $2,300,000. The extent of the outbreak has been reduced from a peak of 2,276,000 acres in 1949 to 1,651,000 acres in 1951, and the area of critical infestation has been reduced from 887,000 acres in 1949 to 82,000 acres in 1951, despite a considerable spread and increase on unsprayed areas. Thus far the fir stands of Oregon and Washington have been successfully protected from heavy losses caused by the budworm. Approximately 640,000 acres are scheduled for spraying in 1952.

Observations made during the past three years at 11,191 check points have revealed that the budworm is present throughout the fir forests of Oregon and Washington with the possible exception of the Olympic Peninsula. So far epidemic infestation in west-side Douglas-fir stands has developed only in the vicinity of Eugene and Roseburg, Oreg.

In a continuation of the effort to reduce the costs of spraying, a large-scale experiment was undertaken in 1951 using 1/4-pound, 1/2-pound, and 3/4-pound concentrations of DDT per acre to determine the feasibility of reducing the amount of DDT. On the 1951 control project at large DDT was applied at the rate of 3/4-pound per acre. Experience gained on the experiment and in the control program indicated that it would be desirable in 1952 to return to the 1-pound per acre rate used in 1949 and 1950, especially in view of the trend toward higher flying for increased pilot safety.

Biological studies of the spruce budworm and its natural control factors were continued. Sample plots on representative unsprayed areas

showed no measurable break in the epidemic that has been in progress since 1944. With the exception of a portion of the Mt. Hood area in Oregon, the budworm population on sprayed areas has continued low since the spraying. There is no evidence that the relative abundance of the parasites of the budworm has been upset by the spraying program.

Douglas-fir Beetle

A study of the Douglas-fir beetle, with special reference to Douglas-fir stands in western Oregon and Washington, was begun in 1946 and is continuing. The study was prompted by sporadic heavy losses of timber, particularly in southwestern Oregon.

The general survey and reinventory of plots in 1951 showed a great increase in losses attributable largely to a build-up of the Douglas-fir beetle in windthrown timber. For example, losses on road-strip plots in Coos County, Oregon, showed the mortality in 1951 to be some 62 percent of the total loss for the years 1946-51, inclusive.

Extensive fires in the summer and fall of 1951 and severe winds in early December 1951 contributed much additional favorable breeding material in the form of fire-killed and windthrown trees for the increase of the beetle population and expansion of the outbreak. A spot check by aerial and ground methods indicated the seriousness of this new threat and provided additional information on the extent and location of the timber killed by beetles in 1951. As a result of this spot check, an intensive survey was planned for the early spring of 1952 to obtain information urgently needed for accelerated salvage operations both to save the dead and down timber and to minimize further spread of the outbreak.

Western Pine Beetle

A general increase of western pine beetle infestation in ponderosa pine in eastern Oregon occurred in 1951. The areas most seriously affected were portions of the Warm Springs Indian Reservation and the Deschutes National Forest, the Chewaucan area of the Fremont National Forest, and areas on the Malheur National Forest previously cut by a 40 percent economic selection system of marking. Sanitation-salvage logging of these centers of increase was recommended to forestall the probable need of direct control at a later date.

Mountain Pine Beetle

An aggressive outbreak of the mountain pine beetle in lodgepole pine on the Wanoga Butte area of the Deschutes National Forest has been in progress for several years. So far this outbreak has affected about 20,000 acres. It is a threat to the extensive stands of lodgepole pine in other portions of Deschutes, Klamath, and Lake Counties, Oregon.

A salvage program undertaken by the Forest Service in the spring of 1951 resulted in the removal of some 4,100 infested trees for use as sawlogs. This program together with some winter killing of the brood during the winter of 1950-51 kept the beetle infestation down to approximately the same level as in 1950. The number of trees infested in 1951 was estimated to be 38,000.

Favorable terrain and good roads make the Wanoga Butte area readily accessible for logging. Salvage of the infested trees is recommended as a means of halting the epidemic without the expenditure of funds for direct control. Some means should be found to utilize the smaller infested trees, down to 5 or 6 inches d.b.h., in order to make salvage fully effective as a control measure.

Fir Engraver Beetles

In 1951 an infestation of fir engraver beetles (Pseudohylesinus) in silver fir in northern Washington expanded to extensive new areas, notably on the west side of the Olympic Peninsula. At present, salvage of infested trees is the only known way to combat the outbreak. Considerable progress is being made in salvaging the timber on the areas of heaviest infestation.

Biological investigations to date indicate that age, vigor, and species composition of the stand are important factors in the outbreak. There is evidence also that soil composition and structure may be of significance. Root rotting fungi have been found to be closely associated with the bark beetles in the killing of silver fir. The total evidence to date is that solution of the fir engraver beetle problem is more likely to be through cutting practice than by direct control measures.

Hemlock Looper

A threatening outbreak of the hemlock looper in the northwestern part of the Olympic Peninsula subsided from natural causes, making it unnecessary to undertake direct control measures. The killing occurred in scattered pockets of hemlock timber of a relatively few acres each. Most of the dead timber will be salvaged.

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